2023-12-04

1127-13

Vol. XI.—No. 49.] [APRIL, 1895.

THE

MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

Mineralogical Society.

INSTITUTED 3rd FEBRUARY, 1876.

EDITED BY H. A. MIERS, M.A.,

Reprinted 1965 for
Wm. DAWSON & SONS LTD., LONDON
with the permission of
THE MINERALOGICAL SOCIETY

Mineralogical Society.

OFFICERS AND COUNCIL FOR 1894-95.

PRESIDENT.

PROFESSOR N. STORY MASKELYNE, M.A., F.R.S.

PAST-PRESIDENTS.

H. C. SORBY, LL.D., F.R.S. 1876–1879.
PROF. M. F. HEDDLE, M.D., F.R.S.E. 1879–1881.
W. H. HUDLESTON, M.A., F.R.S. 1881–1883.
REV. PROF. T. G. BONNEY, D.Sc., F.R.S. 1883–1885.
L. FLETCHER, M.A., F.R.S., 1885-1888.
R. H. SCOTT, M.A., F.R.S., 1888-1891.

VICE-PRESIDENTS.

REV. PROF. S. HAUGHTON, M.D., F.R.S.
HUGO MÜLLER, Ph.D., F.R.S.

TREASURER.

F. W. RUDLER, F.G.S., 28 Jermyn Street, London, S.W.

GENERAL SECRETARY.

L. FLETCHER, M.A., F.R.S., 36 Woodville Road, Ealing.

FOREIGN SECRETARY.

PROF. J. W. JUDD, F.R.S.

PROF. A. H. CHURCH, M.A., F.R.S.
PROF. C. LE NEVE FOSTER, D.Sc., F.R.S.
H. A. MIERS, M.A., F.G.S.
PROF. W. I. MACADAM, F.C.S.
PROF. W. J. LEWIS, M.A., F.C.S.
A. PRINGLE, M.A., B.Sc.
J. STUART THOMSON.
G. T. PRIOR, M.A., F.G.S.
PROF. A. H. GREEN, M.A., F.R.S.
A. HARKER, M.A., F.G.S.
A. E. TUTTON, A.R.C.S., F.C.S.
W. W. WATTS, M.A., F.G.S.

TRUSTEES.

PROF. N. S. MASKELYNE, F.R.S.
R. H. SCOTT, M.A., F.R.S.

AUDITORS.

B. KITTO, F.G.S.
F. RUTLEY, F.G.S.

LIBRARIAN.

PROFESSOR W. J. LEWIS, M.A., F.C.S., The New Museums, Cambridge.
(to whom all publications intended for the Library of the Society should be forwarded).

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, November 20th, 1894.

Prof. N. S. Maskelyne, F.R.S., President, in the Chair.

The Earl of Berkeley, F.G.S., and Mr. William Barlow, F.G.S., were elected Members of the Society.

The death of the Rev. E. Hale and the resignation of Mr. A. Taylor were announced.

The names of two Members were removed from the list for non-payment of subscriptions.

The following dates were selected for the Meetings to be held during the year 1895:—February 5, April 2, June 18, and November 19 (Anniversary).

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, November 20th, 1894.

Prof. N. S. Maskelyne, F.R.S., in the Chair.

Fifteen Members were present.

The following Report of Council for the Session 1893-4 was read by the Secretary:—

REPORT.

The Balance Sheet for the year ending December 31st, 1893, which was issued with Number 48 of the Journal, showed that the state of the finances continued to be satisfactory: the Assets (exclusive of the Stock of the Journal and the Library) amounting to £275 17s. 3d. The number of existing Members who had compounded before December 31st, 1893, for their Annual Subscription was 35.

During the session 1893-4, eight Members have been elected, two Members—the Rev. G. Gordon and the Rev. E. Hale—have died, and one Member has resigned: the names of two non-effective Members have been removed from the List for non payment of subscriptions.

The number of Members of the Society is now 127: of these, 106 are Ordinary Members, 21 are Corresponding Members.

Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological Society, Burlington House.

Two Numbers of the Journal, Nos. 47 and 48, have been issued since the last Anniversary Meeting. Two papers are contributed by Mr. Miers; one of them, written in conjunction with Mr. Prior, is an elaborate discussion of the characters and relations of the minerals Xanthoconite and Rittingerite, and is an appendix to the memoir on the Red Silvers published some years ago in the Magazine; the other describes a rare and beautiful mineral, Spangolite, of which only one specimen was previously known to exist. To Dr. Trechmann the Society is indebted for a paper giving the results of a careful examination of some excellent crystals of Binnite from Imfeld. A paper by Lieut.-Gen. McMahon discusses the optical characters of globules and spherulites of lithium phosphate and some other salts. Mr. Louis has contributed papers descriptive of the Ruby and Sapphire deposits of Moung Klung in Siam, and of the modes of occurrence of Gold: Professor Heddle and Mr. J. S. Thomson, a paper on the "Skin" of Agates: Mr. Rutley, descriptions of Fulgurites from Griqualand, inclusions in Quartz, and cavities in Zircon: Mr. Prior, an Analysis of Fergusonite from Ceylon: Mr. Harker, calculations relative to the extinction-angles in cleavage-flakes: Professors Liversidge and Ulrich, respectively, descriptions of the occurrence of Nantokite in New South Wales, and of Ruby and Margarite at Westland, in New Zealand. An elaborate chemical examination of a New Zealand meteoric stone sent to this country by Professor Ulrich has been made by Mr. Fletcher, whose paper gives the analytical processes and results in a more detailed and systematic manner than has been done by previous investigators, and in such a form as to relieve future analysts of such bodies of a considerable amount of toil.

The Numbers contain also many interesting abstracts of mineralogical papers published elsewhere; for these the Society owes its hearty thanks to Messrs. Harker, Prior, Rutley, and Spencer.

The elaborate Index to the volume has been made by Mr. Miers, who is sparing of no labour in his conduct of the Magazine.

The Society may now congratulate itself on the completion of the first ten volumes of the Journal, and on the maintenance of the high character of the Journal as a scientific publication.

On the motion of the President, seconded by Dr. Hugo Müller, the Report of Council was adopted.

Mr. Kitto and Mr. Tutton, having been nominated to act as scrutineers, reported that 38 voting papers had been returned to the Secretary, and that the following list of Officers and Council was unanimously approved

President.	Prof. N. Story-Maskelyne, M.A., F.R.S.
Vice-Presidents.	Rev. Prof. S. Haughton, M.D , F.R.S.
	Dr. Hugo Müller, Ph.D., F.R.S.
Treasurer.	Mr. F. W. Rudler, F.G.S.
Foreign Secretary.	Prof. J. W. Judd, F.R.S.
General Secretary.	Mr. L. Fletcher, M.A., F.R.S.
Ordinary Members of Council.	Prof. A. H. Church, M.A., F.R.S.
	Prof. C. Le Neve Foster, D.Sc., F.R.S.
	Mr. H. A. Miers, M.A., F.G.S.
	Prof. W. I. Macadam, F.C.S.
	Prof. W. J. Lewis, M.A., F.C.S.
	Mr. A. Pringle, M.A, B.Sc.
	Mr. J. Stuart Thomson.
	Mr. G. T. Prior, M.A., F.G.S.
	Prof. A. H. Green, M.A., F.R.S.
	Mr. A. Harker, M.A., F.G.S.
	Mr. A. E. Tutton, A.R.C.S., F.C.S
	Mr. W. W. Watts, M.A., F.G.S.

A vote of thanks to the Auditors (Mr. Kitto and Mr. Rutley) was passed, and the Auditors were re-elected.

Votes of thanks were also passed to the retiring Members of Council (the Rev. H. P. Gurney, Prof. Liveing, Lieut.-Gen. McMahon, and Mr. Teall), and to the Geological Society for the use of its Apartments.

The following papers were then read:—

1. On Cone-in-Cone Structure: by the Rev. Prof. T. G. Bonney, D.Sc., F.R.S. (Page 24.)

2. On a Basic Ferric Sulphate from Parys Mount, Anglesey: by Prof. A. H. Church, M.A., F.R.S. (Page 13.)

3. Augelite: by Mr. G. T. Prior, M.A., F.G.S., and Mr. L. J. Spencer, B.A., F.G.S. (Page 16.)

4. On the Occurrence of Delessite in Cantyre: by Professor M. F. Heddle, F.R.S.E., and Mr. J. S. Thomson. (Page 28.)

Specimens were exhibited in illustration of the paper on Augelite: also a beautiful opal-cast of a bivalve from Australia.

Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December 1894.

RECEIPTS.

	£ s. d.	£ s. d.
Balance from year 1893:—		
(1) In Bank	19 18 6	
(2) In Office	0 13 4	
		20 11 10
Subscriptions:—		
(1) In advance	4 4 0	
(2) Current	51 9 0	
(3) In arrear	8 8 0	
		64 1 0
Entrance Fees and Compositions		28 7 0
Sale of Journal:—		
(1) By Publishers	15 14 0	
(2) At Office	2 18 1½	
		18 12 1½
Dividends on Stock		7 6 8
Authors' extra separate copies		4 0 0
Donation for Illustration (Mr. Rutley)		1 16 3
		£144 14 10½

PAYMENTS.

	£ s. d.
Printing and Stationery	88 6 9
Illustrations	8 4 6
Attendance at Meetings	1 1 0
Editorial and Clerical Expenses	Nil
Postage, Parcels, &c.	1 10 9
Insurance of Stock of Journal	1 8 0
Investments and Commission	7 6 8
Bank Commission on Cheques	0 2 6
Stamps on 60 Cheques	0 5 0
Cash in Office on 31st December, 1894	2 3 2½
Balance in Bank on ditto	34 6 6
	£144 14 10½

Examined and compared with the vouchers and found correct. (Signed)

BENEDICT KITTO, } *Auditors.*
FRANK RUTLEY, }

February 26th, 1895.

LIABILITIES.

	£ s. d.
Printing and Stationery	4 19 7
Illustrations	0 13 6
Secretarial and Editorial Postage	0 6 6
Excess of Assets over Liabilities	382 6 1½
	£388 5 8½

The number of Life Members on December 31st, 1894, was 37.

ASSETS.

	£ s. d.
Balance at the Bank	34 6 6
Cash in Office	2 3 2½
Subscriptions for 1891-4 unpaid	29 8 0
Stock in 2¾ per cent.: £287 6s. 3d. at 104...	298 16 1
Dividend on Stock, January 1895	1 17 3
Sale of Journal	16 17 5
Due for Authors' separate Copies	4 17 3
	£388 5 8½

MEMO.—The Stock of Publications and the Library are not included in the above assets.

(Signed) F. W. RUDLER,
Treasurer.

THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY.

No. 49. APRIL, 1895. Vol XI.

A Chemical Study of Some Native Arsenates and Phosphates.

1. Euchroite. 2. Liroconite. 3. Clinoclase. 4. Tyrolite. 5. Pharmacolite. 6. Cacoxenite. 7. Kühnite.

By A. H. Church, M.A., F.R.S.

[Read June 19th, 1894.]

THE present series of notes is mainly based upon analyses executed during the years 1867-1877, but these have been supplemented in a few instances by recent work. The series may be regarded as a continuation of several papers published from time to time in the *Journal of the Chemical Society*, in the *Chemical News*, and in the *Proceedings of the Royal Irish Academy*. Throughout these inquiries particular attention has been paid to the degree of tenacity with which the water present in the hydrous species is held.

1. Euchroite.

A fine specimen of this mineral from Libethen, Hungary, was submitted to analysis in the year 1874. As the results simply confirmed the

accepted composition of the species, they remained unpublished. But, on looking lately into the record of my analysis, I noted the hitherto unrecorded presence of phosphoric acid in this mineral. As the observation is of interest in connection with other native arsenates, and offers a parallel to the partial replacement of phosphorus by arsenic in some mineral phosphates, a brief note on the subject may be not unacceptable to mineralogists.

The specific gravity of the specimen was 3·42 at $\frac{16°·5}{15°·5}$C. This determination was made in alcohol of sp. gr. ·8892 at 16°·5. The balance used was an assay balance by the late L. Oertling, and was specially arranged for the purpose of taking specific gravities. The crystal of euchroite employed weighed ·4639 gram.

The following figures represent the analytical results with the corresponding percentages :—

Euchroite taken	·7365 gram		
Water lost *in vacuo*	·009	,, = 1·22	per cent.
Water lost at 100° C. ...	·014	,, = 1·90	,,
Water lost at low redness ...	·119	,, =16·16	,,
Water, total	·142	,, =19·28	,,
Cupric oxide	·3481	,, =47·26	,,
2 $MgNH_4AsO_4$, H_2O	·376	,, =30·90	,, As_2O_5
$Mg_2P_2O_7$	·017	,, = 1·48	,, P_2O_5
Undetermined	...	... 1·08	,,

The formula of euchroite, 4 CuO. As_2O_5. $7H_2O$, as deduced from the analysis of Kühn and Wöhler, is in accord with the percentages given in the present note. For the purpose of comparison, I have converted the percentage of P_2O_5 into its equivalent of As_2O_5 :—

	Theory		Experiment
4CuO	47·12 per cent.	...	47·26 per cent.
As_2O_5	34·16 ,,	...	33·29 ,,
$7H_2O$	18·72 ,,	...	19·28 ,,

It might be argued that the loss of water *in vacuo* and at 100° indicates the existence in this mineral of one molecule of cupric hydrate. This loss does indeed correspond pretty nearly to that demanded by such a formula as

$$3CuO.\ As_2O_5.\ 6H_2O + CuO.\ H_2O,$$

if we deduct a small quantity—something less than 0·5 per cent.—of accidental or hygroscopic moisture. But if one-fourth of the copper present in euchroite exist in the form of cupric hydrate, it is hardly likely that the

mineral would become yellowish-green and not blacken on being strongly heated. One may, however, affirm that one of the seven molecules of water in this mineral is less firmly retained than the remaining six. It is worth while comparing the theoretical and experimental percentages of water corresponding to 1 and to 6 molecules :—

	Theory	Experiment
H_2O	2·67	3·12
$6H_2O$	16·05	16·16

2. Liroconite.

A fine specimen of Cornish liroconite was analysed in 1874. Its specific gravity, determined with the same precautions as those observed in the case of euchroite, proved to be 2·97 at $\frac{16°·5}{15°·5}$ The analysis, though incomplete, shows that the water in this mineral is not all retained with equal tenacity :—

Liroconite taken	·812 gram		
Water lost *in vacuo*	·052 ,,	= 6·40 per cent.	
Water lost at 100° C. ...	·080 ,,	= 9·85 ,,	
Cupric oxide	·2983 ,,	=36·73 ,,	
2 $MgNH_4AsO_4$, H_2O	·320 ,,	=23·85 ,,	As_2O_5
$Mg_2P_2O_7$	·013 ,,	= 1·02 ,,	P_2O_5

These results, so far as they go, are not inconsistent with the percentages demanded by the expression $4CuO.\ Al_2O_3.\ As_2O_5.\ 13H_2O$. In this formula $3H_2O$ correspond to 6·12 per cent. water, which may be represented by the loss suffered by liroconite *in vacuo*. Similarly, the further loss of 9·85 per cent. sustained at 100° may indicate the separation of $5H_2O$, which theoretically demands 10·19 per cent. The formula above given requires the following percentages :—

$4CuO$	=317·2=35·92	per cent.
Al_2O_3	=102·0=11·35	,,
As_2O_5	=230·0=26·04	,,
$13H_2O$	=234·0=26·49	,,

Although these theoretical numbers agree fairly with the analytical results hitherto published, the empirical formula which they suggest

$$\left.\begin{matrix} 3CuO.\ As_2O_5 \\ CuO.\ H_2O \\ Al_2O_3.\ 3H_2O \end{matrix}\right\} 9\ aq$$

is not in precise accord with the losses of water which this mineral suffers

in vacuo and at 100°. As I have pointed out elsewhere,[1] the native normal aluminium hydrate, gibbsite, loses no water *in vacuo* or even at 100° : this observation does not lend support to the view that $Al_2O_3 . 3H_2O$ exists as such in liroconite. Reasoning from the analogy of variscite, a normal native aluminium phosphate, which loses all its water at 100°, it might be concluded that a corresponding aluminium arsenate exists in liroconite : if this be the case, the formula for this species might be written :—

$$\left.\begin{matrix} Al_2O_3 . As_2O_5 . 4H_2O \\ 4(CuO . H_2O) \end{matrix}\right\} 5H_2O$$

Unfortunately it is not possible to bring the loss of $3H_2O$ *in vacuo*, and of $5H_2O$ at 100°, into harmony with this expression. So, for the present and until further experimental evidence has been accumulated, we must be content with such a formula as this[2] :—

$$4CuO . Al_2O_3 . As_2O_5 . 5H_2O + 5H_2O + 3H_2O$$

3. Clinoclase.

The mineral clinoclase had been analysed with concordant results by Rammelsberg and by Damour when, in the year 1867, I came into possession of a particularly fine specimen. In studying the group of arsenates and phosphates to which this species belongs, I was anxious to ascertain the degree of tenacity with which the water present in the mineral was retained. I found that *in vacuo* and at 100° C. the finely powdered substance lost no more than ·08 per cent. of moisture. This having been deducted, the percentages of constitutional water, of arsenic pentoxide, and of cupric oxide were determined to be :—

	Experiment.	*Theory.*
		$3CuO . As_2O_5 . 3(CuO, H_2O)$
Water (by difference) ...	7·20 ...	7·11
Arsenic pentoxide ...	30·08 ...	30·27
Cupric oxide ...	62·72 ...	62·62

The arsenic was weighed as $2MgNH_4AsO_4 . H_2O$. On further examination of this salt it was found to contain a minute trace of the corresponding phosphate.

---

[1] "On the Constitution of the Native Phosphates of Aluminium." *Proc. R. Irish Academy*. Ser. II., Vol. III., pp. 551-562 (1882).

[2] It would be convenient if different founts of type (black letter italic, for example) could be employed to discriminate molecules of H_2O held with different degrees of tenacity.

4. Tyrolite.

In a paper published in 1873 (*Chem. Soc. J.* XXVII., 108) I gave the results of some analyses of tyrolite. The specimen examined was conjectured to have come from Libethen, but recent study of its matrix leads me to assign it to Falkenstein. In the above paper tyrolite was stated to contain "calcium carbonate as an essential ingredient not as an accidental impurity." This position, confirmed as it is by the results of three analysts working independently, is not accepted by Professor E. S. Dana (*Mineralogy*, 6th ed., p. 839), whose opinion is obviously influenced by the results of several recent analyses of a mineral from the Mammoth Mine in the Tintic District of Utah. After a careful comparison of the Utah and Falkenstein minerals, I am bound to confess that they appear to belong to the same species. About the same proportion of lime occurs in both. May not the absence of carbon dioxide from the former be explicable by means of the theory that it is represented by some other acid constituent? Anyhow, I am now in a position to offer fresh evidence in favour of my original view. Fortunately, I had preserved several grams of the tyrolite with which I had worked in 1872-3.

The following experiment seems to be decisive. A portion of the mineral, carefully selected, was ground to an impalpable powder and suspended in distilled water. A current of carbon dioxide was then passed through the mixture for some hours. The liquid was filtered, then the clear filtrate was tested for calcium with a positive result. But as copper and arsenic pentoxide were also found in the liquid it became necessary to ascertain the *proportion* of calcium to copper present therein. These metals occurred in the ratio of 1 : 5, the precise ratio in which they exist in the original mineral. As it is inconceivable that calcium carbonate and pentabasic cupric arsenate should possess identical solubilities in carbonated water, it is evident that the mineral tyrolite dissolves *as a whole* in that solvent. This conclusion is greatly strengthened by a further observation accidentally made during the course of the above described experiment. About 100 cc. of the clear filtrate, prepared as just mentioned, were left in a beaker for 48 hours. At the end of that time it was noticed that the liquid was no longer clear. There was a film on its surface and numerous shining particles were floating in it. Both film and particles presented the precise greenish-blue colour and satiny aspect of the original tyrolite; neither could be mistaken for the calcium carbonate which would have been precipitated had the carbonated water simply withdrawn that compound from a mineral in which it existed in admix-

ture. That no carbon dioxide can be found in the Utah mineral, if it be a different species, would have no bearing on these facts. But if the American and the European minerals be really identical the absence from the former of carbon dioxide may be explicable on the theory of substitution. In further confirmation of the view that calcium carbonate does not exist as an intruding substance in tyrolite, I may state that when the coarsely powdered mineral is dissolving in acid it continues to evolve minute bubbles of carbon dioxide so long as a particle remains.

But if the view I formerly propounded as to the relation subsisting between the calcium carbonate in tyrolite and its other constituents has now been confirmed, yet the formula which I proposed in 1873 for this species needs modification in one particular. For I certainly misinterpreted the meaning of the phenomena which I had then observed as to the loss of water sustained by tyrolite when kept *in vacuo*, or heated to 100 C. Such loss, amounting to 7 or 8 per cent., does *not* represent accidental or hygroscopic water, but corresponds to a definite number of molecules of H_2O. An appearance, which I had observed and had attributed to the presence of interstitial water between the laminæ of the crystals in their central portions, is due to an optical illusion arising from the perfect contact of these portions. So many cases are now known where essential water is lost by minerals, and especially by arsenates and phosphates, when subjected to the influence of dry air or of lowered barometric pressure, that one need feel no surprise at the discovery of another instance of this phenomenon.

In the original paper (*loc. cit.*) to which reference has been made, there occurred an error in the substitution of the symbol for phosphorus for that of arsenic. It may be well, therefore, to reproduce here the figures of the more complete of the two analyses previously published, and at the same time to set down the water found in the mineral in accordance with the view as to its function which must now be held. These are the figures of analysis ii. :—

Tyrolite taken	·4585 gram		
Water lost *in vacuo*	·024	,, = 5·23	per cent.
Water lost at 100° C. ...	·011	,, = 2·40	,,
Calcium carbonate	·0505	,, =11·01	,,
Cupric oxide	·212	,, =46·24	,,
2 $MgNH_4AsO_4$, H_2O	·205	,, =27·07	,, As_2O_5
Water retained at 100°, by difference ...	...	8·05	,,

Here is the comparison between these experimental percentages and those demanded by the expression—5 CuO. As_2O_5. $CaCO_3$. 8 H_2O

	Experiment	Theory
CuO	46·24	45·55
As_2O_5	27·07	26·42
$CaCO_3$	11·01	11·49
H_2O	15·68	16·54

As the loss of water suffered by tyrolite *in vacuo* and at 100° C. is half of its total content, the formula of the species may be written :—

$$\left.\begin{matrix} Cu_3As_2O_8.\ 2H_2O \\ CaCO_3 \\ 2Cu(OH)_2 \end{matrix}\right\} 4H_2O$$

The slight deficiency in the experimental percentage of water which corresponds to the $4H_2O$ in the above formula is probably attributable to the imperfect methods of desiccation adopted; for in many similar cases it is observable that a really good vacuum and the actual temperature of 100° C. (and not the heat attained in the water-oven) are required in order to secure the complete expulsion of the loosely-attached molecules of water.

5. Pharmacolite.

An incomplete analysis of well crystallised pharmacolite furnishes another example of a perfectly definite mineral species which loses much constitutional water at the ordinary temperature *in vacuo*. The following figures represent the analytical results with the corresponding percentages :—

Pharmacolite taken	·962 gram	
Water lost *in vacuo* at 16° C.	·1155 gram = 12·37 per ct.	after deduction of silica, &c.
Water lost between 100° & 200°	·029 ,, = 3·11 ,,	
Silica and insoluble matter	·028 ,,	

The composition of pharmacolite is usually represented by the formula 2CaO. H_2O. As_2O_5. 5aq. From the desiccation experiments above recorded it would seem that $3H_2O$ are lost *in vacuo*, and $1H_2O$ at temperatures up to 200°. For $3H_2O$ are equal to a percentage of 12·0, while $1H_2O$ corresponds to 4·0 per cent., while experiment gave, respectively, 12·37 and 3·11, or a total of 15·48 per cent. against the 16 per cent. re-

quired by theory for $4H_2O$. If these conclusions be correct we shall have these expressions for

Pharmacolite in normal state	...	...	$2CaO.\ H_2O.\ As_2O_5.\ 5aq.$
Pharmacolite dried *in vacuo* at 16°	...	...	$2CaO.\ H_2O.\ As_2O_5.\ 2aq.$
Pharmacolite dried at 200°	...	...	$2CaO.\ H_2O.\ As_2O_5.\ 1aq.$

Rammelsberg[1] has pointed out that the second of these formulæ represents the species haidingerite, but his remark seems to be based on the observations of Petersen, who found that pharmacolite suffered a loss of 11 to 12 per cent. of water on being heated to 100° C. That such loss occurs by reduction of pressure only, without having recourse to increase of temperature, does not appear to have been hitherto recorded.

It should be noted that in the new (1892) edition of Dana's *Mineralogy* pharmacolite is assumed to contain one molecule less of water than is assigned to this species in the present note. All the results obtained in the analysis of the native compound confirm the view here adopted.

It may be mentioned here that a specimen of pharmacolite which presented the more transparent aspect of haidingerite furnished me with analytical results confirming those just given as regards the water in this species. In this case the lime and the arsenic pentoxide were also determined, the percentage of the former constituent being 25·04, of the latter 47·95. This latter percentage is indeed about 8 units lower than that demanded by theory, but it is still less in accord with the number (53·3) required by a formula having $5H_2O$ instead of $6H_2O$.

6. Cacoxenite.

Having sacrificed a very fine specimen of this mineral, from Hrbek, near St. Benigna, in Bohemia, I obtained sufficient material for analysis. The deep gold-coloured acicular crystals were separated as far as possible by mechanical means from the traces of impurities which had been detached from the matrix. In dissolving the selected material in dilute hydrochloric acid, the process of solution was not urged forward to its extreme limit. In calculating the percentages given below, the matter which was not dissolved by the acid, and the trace of silica subsequently separated, together amounting to 6·15 per cent., were previously deducted. Much water was lost by the mineral *in vacuo* over oil of vitriol, but none in the air-bath at 100° C.

[1] *Mineral-Chemie.* 2te Auflage, p. 339.

	Experiment	Theory
Water lost *in vacuo* over H_2SO_4 ...	18·69 ...	18·45
Water (with trace of F) lost on ignition ...	13·11 ...	12·92
Ferric oxide	48·57 ...	49·22
Phosphorus pentoxide	19·76 ...	19·41

These figures correspond with the formula

$$9Fe_2O_3.\ 4P_2O_5.\ 51H_2O,$$

which demands the percentages placed by the side of the experimental numbers. In these theoretical percentages I have divided the 51 molecules of water into two groups, one consisting of 30 molecules and the other of 21 ; it will be observed that the percentage of water lost *in vacuo* corresponds very closely with that demanded by the escape of $30H_2O$. This observation is consistent with such a formula as the following :—

$$\left.\begin{matrix}4\ (Fe_2O_3.\ P_2O_5.\ 4H_2O)\\ 5\ (Fe_2O_3.\ H_2O)\end{matrix}\right\} 30H_2O$$

This expression is doubtless somewhat complex, and I am not prepared to maintain that the substance analysed was perfectly homogeneous. The results of the analysis might be said to represent a mixture of about one molecule of limnite ($Fe_2O_3.\ 3H_2O$) or of xanthosiderite ($Fe_2O_3.\ 2H_2O$) with four molecules of a basic ferric phosphate having the comparatively simple formula :—

$$\left.\begin{matrix}Fe_2O_3.\ P_2O_5.\ 3H_2O\\ Fe_2O_3.\ 2H_2O\end{matrix}\right\} 7H_2O$$

It will, however, be seen on comparing the percentages demanded by this last formula with those obtained in the analysis of cacoxenite, that they agree fairly well even if we make no allowance for the supposed presence of an excess of some ferric hydrate such as xanthosiderite. Here are the percentages in question :—

		Theory		Experiment
		$\left.\begin{matrix}Fe_2O_3.\ P_2O_5.\ 3H_2O\\ Fe_2O_3.\ 2H_2O\end{matrix}\right\} 7H_2O$		
$2Fe_2O_3$ ...	320 ...	47·20 ...		48·57
P_2O_5 ...	142 ...	20·94 ...		19·76
$5H_2O$ ...	90 ...	13·28 ...		13·11[1]
$7H_2O$ ...	126 ...	18·58 ...		18·69[2]
		100·00		

[1] lost *in vacuo*. [2] lost on ignition.

I am inclined to think that the above formula may be accepted as that of cacoxenite. It is in fair agreement with the analytical results obtained by v. Hauer in one of his analyses of the Hrbek mineral: a higher percentage of P_2O_5 and less Fe_2O_3 are shown in the two other analyses cited by Dana. But to whatever conclusions further work on cacoxenite may lead, the experiments now placed on record prove, for the first time, that $\frac{7}{12}$ths of the water present in this mineral are retained with far less tenacity than the remaining $\frac{5}{12}$ths.

8. Kühnite.

In the year 1876 I acquired a specimen of a honey-yellow mineral labelled "Chondrarsenite, Långban, Sweden. Quantitative analysis showed that the substance differed from chondrarsenite in containing far less manganese but much more lime and magnesia than that species, and that its blow-pipe reactions were not the same. In fact it bore a very close resemblance to another arsenate of lime, magnesia, and manganese, which was analysed by Kühn (*Liebig Annal.*, XXXIV., 211, 1840), and named by him *Berzeliite*. It occurred in irregular crystalline masses imbedded in a granular limestone and accompanied by hausmannite. It lost nothing *in vacuo* or at 100° (in one experiment the loss on 1·0928 gram was ·0004 gram), but gave a small amount of residue insoluble in acid (·0025 gram from ·3874 gram of mineral; ·002 from ·294; ·001 from ·226; and ·002 from ·3245). The following figures represent the analytical results with the corresponding percentages, the insoluble matter having been in all cases deducted:—

I.	Mineral taken ...	·3849 gram			
	$2\,MgNH_4AsO_4, H_2O$	·358 ,,	=56·29	per cent.	As_2O_5
II.	Mineral taken ...	·292 ,,			
	$2\,MgNH_4AsO_4, H_2O$	·2758 ,,	=56·21	,,	As_2O_5
	$CaCO_3$	·1115 ,,	=21·38	,,	CaO
III.	Mineral taken ...	·225 ,,			
	Mn_3O_4	·008 ,,	= 3·52	,,	MnO
	$CaCO_3$	·0905 ,,	=22·52	,,	CaO
	$Mg_2P_2O_7$	·079 ,,	=12·65	,,	MgO
IV.	Mineral taken ...	·3225 ,,			
	Mn_3O_4	·0105 ,,	= 3·04	,,	MnO
	$CaCO_3$	·1205 ,,	=20·92	,,	CaO
	$Mg_2P_2O_7$	·1195 ,,	=13·35	,,	MgO

The mean percentages are :—

CaO	21·61
MgO	13·00
MnO	3·28
As_2O_5	56·25
Deficiency ...	5·86
	100·00

The questions naturally arise " what constituent of the mineral has been missed ? " and " was water present ? " Kühn had indeed noticed a loss on ignition of his mineral, equal in one case to 0·3 per cent. ; in another to 2·95 per cent. ; but he did not prove such loss to arise from the escape of water. In order to determine the point I heated to very low redness a most carefully selected sample of the mineral, and found that the loss on 1·539 gram amounted to 0·004 gram only, or 0·26 per cent. —a negligible quantity. The species is obviously anhydrous. But an explanation of the analytical deficit was soon discovered. On dissolving the finely powdered mineral in dilute hydrochloric acid a brisk evolution of a gas which proved to be carbon dioxide was observed. No selection, however careful, of the fragments of the crushed mineral could eliminate the substance giving rise to this effervescence, and I am forced to conclude that the embedded nodules of Kühnite are interpenetrated with the calcareous matrix in which they occur. If this conclusion be just, we may look upon the substance analysed as an intimate mixture of true kühnite with about 7 per cent. of calcite, kühnite itself being represented by the formula $(CaMgMn)_3As_2O_8$. The analytical results correspond fairly well with the expanded formula — 4·5CaO. 4MgO. 0·5MnO. $3As_2O_5$, although nearly 2 per cent. of the constituents of the mineral remain still unaccounted for.

Thus far had I written, in recording the results obtained by me in 1876, when I observed, on referring to the 1892 edition of Dana's *Mineralogy*, that some work has been done during recent years towards clearing away the obscurity in which the constitution of kühnite was involved. In the variety known as pyrrhoarsenite carbon dioxide has been found to the extent of between 1 and 2 per cent. This result confirms the observation already recorded in the present note, and is probably to be explained in the same way. As ordinary kühnite is isometric, I asked Mr.

Miers to examine optically some fragments of the specimen which I had analysed. He tells me that the appearance of the mineral in polarised light is in accord with my view that it consists of an isometric compound interpenetrated with small particles of calcite. It seems, however, t at a doubly-refracting arsenate, having the same composition as kühnite, also exists. It is the pseudoberzeliite of W. Lindgren, and also the similar mineral from the Moss Mine, Nordmark, described by Igelström (Dana, *Min.*, 6th ed., p. 753).

A Basic Ferric Sulphate, from Parys Mount, Anglesey.

By A. H. Church, F.R.S.

[Read November 20th, 1894.]

AN orange-coloured ochreous substance from Parys Mount, Anglesey, was recently submitted to analysis. It gave the following percentages :—

		Silica deducted.
Water lost at 100° C	13·51	
Water lost on moderate ignition ...	12·85	26·94
Sulphur trioxide	13·44	.. 13·74
Ferric oxide	57·85	... 59·12
Silica	2·14	
Alumina, Lime, &c. (by difference) ...	·21	
	100·00	

The formula $2Fe_2O_3$. SO_3. $8H_2O$ requires these percentages :—

Water	26·47
Ferric oxide	58·83
Sulphur trioxide ...	14·70

The observed loss of water at 100° corresponds to $4H_2O$, which requires 13·24 per cent. If we assume that the molecular weight of this sulphate is thrice that represented by the empirical formula above given, we shall arrive at the expression for a hexabasic compound :—

$$Fe_2O_3.\ 3SO_3.\ 5Fe_2O\ .\ 24H_2O.$$

This corresponds to the body described by Berzelius as gradually produced, in the form of a yellow precipitate, by exposing a solution of green vitriol to the air. More recently O. Meister has described (*Deutsch. Chem. Gesell.* 1875, p. 771) a similar body to which he assigned the formula $2Fe_2O_3$, SO_3, $7H_2O$. He obtained this salt by washing with cold water a crystallised and less basic sulphate—Fe_2O_3. $2SO_3$. $15H_2O$. As the

mineral now under discussion loses half its water at 100°, it may, after drying at that temperature, be represented by the formula—

$$Fe_2O_3.\ 3SO_3.\ 5Fe_2O_3.\ 12H_2O.$$

The mineral, in its natural condition, corresponds to a compound of one molecule of normal ferric sulphate, or *coquimbite*, with 5 molecules of normal ferric hydrate :—

$$\left.\begin{matrix} Fe_2O_3.\ 3SO_3.\ 9H_2O \\ 5\ (Fe_2O_3.\ 3H_2O) \end{matrix}\right\}$$

After drying at 100° it may become :—

$$\left.\begin{matrix} Fe_2O_3.\ 3SO_3.7H_2O \\ 5\ (Fe_2O_3.\ H_2O) \end{matrix}\right\}$$

But the physical properties of our mineral are not those which would be expected in a compound such as that which we have imagined, and it therefore seems better to take the simplest possible formula for it, and to regard the mineral as a single chemical entity :—

$$\left.\begin{matrix} Fe'''_4 \\ H_4 \end{matrix}\right\} \left\{\begin{matrix} O_5 \\ SO_4 \\ (OH)_4 \end{matrix}\right\} 4\ aq$$

In this case the 4 aq. outside the compound proper represent the water lost at 100°. The *glockerite* of Naumann may be written in the same manner, but with 2 aq. instead of 4 aq.

This mineral, in the lump or in powder, appears of a deep yellow and is quite opaque to the unassisted eye. But when viewed in the microscope with a sufficient magnifying power, the individual particles of which it consists are seen to be transparent, or at least translucent, and crystalline. In polarised light they seem to be isometric.

Although the result of the action of atmospheric oxygen and of water upon ferrous sulphate, it is doubtful whether the product described in the present note can be fairly regarded as entirely natural. Possibly the ferrous sulphate from which it has been derived may have been formed, not directly from iron pyrites, but from scrap iron reacting upon the copper sulphate occurring in the waste waters of a mine. However, there can be no doubt that the ferric sulphate above described frequently occurs as a wholly natural product.

Occurrence of Mispickel in the Stewartry of Kirkcudbright.

By P. Dudgeon, F.R.S.E.

[Read June 19th, 1894.]

HAVING heard that a vein of what was supposed to be mispickel had been found about 6 miles north of Newton Stewart, in company with Professor Heddle I visited the place a week or two since. We found the vein had been opened in two places and some of the mineral had been taken out. It proved to be mispickel. The vein runs pretty nearly north and south: it occurs at the junction of the granite and silurian rocks, commencing about half-a-mile south of the Murray monument, crossing the Palnure Burn, running nearly due south for more than a mile, and then heading to the eastward, where, at about three-quarters of a mile further on, another opening has been made in which is found chalcopyrite associated with mispickel. The vein, where it has been opened close to the Palnure Burn, is about 7 inches wide, and contains only mispickel. The interest to be attached to this discovery is that mispickel is an exceedingly rare mineral in Scotland, in fact only one rather doubtful locality is mentioned in mineralogical works.

Augelite.

By G. T. Prior, M.A., F.G.S., and L. J. Spencer, B.A., F.G.S.

[Read November 20th, 1894.]

AUGELITE was one of several aluminium phosphates from the iron mine of Westanå, Skåne, Sweden, described by C. W. Blomstrand in 1868 (*Öfv. Ak. Förh. Stockh.* XXV. 1868, p. 199). He states it to be a massive mineral with distinct cleavages in three directions, and names it augelite (*αυγη* lustre) on account of the strong pearly lustre on the cleavage surfaces. He determines its specific gravity as 2·77, and, as the result of his analyses, represents its chemical composition by the formula, $2Al_2O_3.\ P_2O_5.\ 3H_2O$. Since this paper of Blomstrand, as far as we are aware, no further reference to augelite has been made, and, since hitherto distinct crystals of the mineral have not been found, its position as a definite species seems to have been regarded as somewhat doubtful, for we find that Dana, in the last edition of the *System of Mineralogy*, includes it in a rather unsatisfactory group of more or less doubtful species appended to evansite.

The crystals of augelite which supplied the material for the physical and chemical determinations given in the following paper, were found associated with the bournonite and octahedral pyrites from Machacamarca, Bolivia.[1] Almost all the bournonite specimens from this locality in the British Museum collection showed augelite, either filling cavities in the bournonite, or in isolated crystals upon, and lining crevices in, the quartzose matrix (consisting of angular quartz grains with interspersed iron pyrites) on which the bournonite was deposited. The crystals are of small size, the largest not measuring more than 6·5mm., and the majority not more than 3 to 4mm. along their greatest diameter. The crystallographic measurements were for the most part made on still smaller crystals found embedded in a yellow crumbling decomposition product from the pyrites and bournonite, which coated one side of a large specimen of bournonite.

[1] There seem to be at least three places called Machacamarca in Bolivia, two in Oruro, and one in Potosi.

Crystalline Form.

Monosymmetric. $a : b : c = 1{\cdot}6419 : 1 : 1{\cdot}2708$. $\beta = 67°33\frac{1}{3}'$

$100 : 110 = 56°37'$; $001 : 101 = 28°54\frac{1}{2}'$; $001 : 011 = 49°35\frac{1}{2}'$.

Observed Forms.—*c* (001), *m* (110), *x* ($\bar{1}01$), *f* (101), *a* (100), *b*(010), *n* (112), *r* (011), *o* ($\bar{1}12$).

Doubtful forms—225, 334, 223, 665, 221, 530, 310 in the zones *cm* and *mm*.

Besides these there were other indefinite reflections in the zones *cm*, *mm*, *xm*, *ca*.

	Calculated.	Measured.	Limits.	No. of Observations.
ac	67°33½′	67°34′	67°24′ —67°39′	3
af	38°39′	38°37′	38°31′ —38°43½′	2
cf	28°54½′	28°43′	28°30½′—28°54′	7
cx	45°26½′	45°22′	44°36′ —46° 4½′	24
xm	77°35½′	77°40′	77°29′ —78° 6′	19
cn	31° 7½′	31° 9′	30°41½′—31°19′	9
**mc*	—	77°52½′	77°46′ —77°59′	20
**mm*	—	66°46′	66°28′ —67° 7′	32
**fm*	—	64°33′	64°27′ —64°38′	12
fn	28°26′	28°24½′	28°13′ —28°30½′	2
fr	55°25½′	55°13′	..	1
an	54°53′	54°55′	54°36½′—55° 8½′	4
cr	49°35½′	—	..	..
c : 111	45°42½′	—	..	..
co	39°11½′	39° 9½′	..	2

Doubtful Forms.

225 : *c*	26°20	26°18′	..	1
334 : *c*	40°11½′	40°24′	39°0′—40°56′	3
665 : *c*	50°37′	50°30′	..	1
221 : *c*	59°57½′	60°	..	1
530 : *m*	14°18′	14°30′	14°—15°	2
310 : *m*	29°47′	29°19′	..	1

The basal plane is usually represented by one or more *vicinal faces* which lie in the zones *cx* and *cm*, and are generally the brightest faces, giving the best images. On account of these vicinal faces, the measurements from the prism plane varied from 77° 19½′ to 79° 31′ (number of observations 87). Within these limits they fell into five fairly well marked groups of which the means were 77° 29′, 77° 45′, 77° 52½′, 78° 2′, 78° 24′. The third of these measurements (77° 52½′) was taken as the true angle *cm*, for the calculated angles between other faces were found to be in closer agreement with the measured angles when this value, instead of any of the other four, was given to *cm*. The first two measurements

will then be due to vicinal faces in the zone cm at $7\frac{1}{2}'$ and $23\frac{1}{2}'$ from c, and the last two to vicinal faces in the zone cx at $18\frac{1}{4}'$ and $1° 0\frac{1}{2}'$ from c (towards x).

Characters of the faces :—

c. Smooth to deeply striated parallel to its intersections with x and m; the vicinal faces in the zone cx are striated parallel to their intersections with x, and those in the zone cm to their intersections with m. The basal plane is often represented by only one of the vicinal faces, which is very smooth and bright, giving a single sharp image.

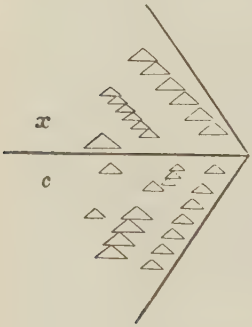


Fig. 1.

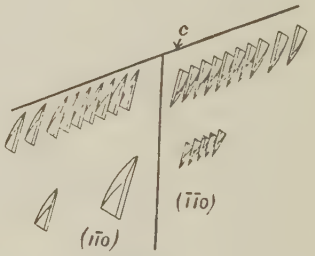


Fig. 2.

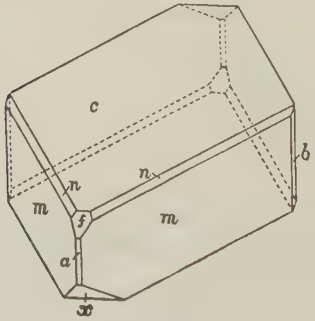


Fig. 3.

x. Usually rough and pitted; striated parallel to its intersections with c and m; rarely smooth.

m. Smooth and bright; striated parallel to the prism edges, and sometimes very faintly parallel to its intersection with c.

f. Small and bright.

n. Small narrow plane, which, with several indistinct planes (see list of doubtful forms above), truncates the edge *cm*.

Habits:—

(1.) The most common habit is tabular parallel to *c* (Fig. 3), with only the forms *c* and *m* prominent. The isolated crystals on the quartzose matrix usually assume this habit.

(2.) Thin triangular plates tabular parallel to *m*, with the edges bounded by *c*, *x*, and *m*.

(3.) Prismatic, with *c* and *x* equally developed, closely simulating rhombic crystals since the angles *cm* and *xm* are so nearly equal.

The crystals found embedded in the yellow decomposition product were of the two last habits.

Etching:—

Many of the crystals, especially those from the decomposition product, showed well marked etch-figures, and similar figures could be easily produced by heating crystals for a short time in hydrochloric acid. In Fig. 1 are shown the etchings on the *c* and *x* planes, and in Fig. 2 those on the prism planes. In their form they accord with the oblique symmetry of the crystals. As seen in the figure, they are generally arranged in lines parallel or nearly parallel to one, and one only, of the prism edges. This would seem to suggest a hemimorphic development of the crystals, and this idea receives some slight support from the fact that on one crystal the striations observed on the *x* plane were again only parallel to one of the prism edges. Hemimorphism was also suggested by the development of the form *n* on one or two crystals. No pyroelectricity on change of temperature, however, could be detected by means of Kundt's method.

Physical Characters:—

Colourless to white; transparent to translucent; streak white; lustre vitreous, inclining to pearly on the cleavage surfaces. Cleavage: *m* perfect; *x* less perfect, but good. Fracture uneven.

Hardness 4·5 to 5: brittle.

Density (weight of 1cc.) 2·696 at 22°C; material used 0·4166 gr.

Under the microscope, in some of the crystals, liquid cavities with bubbles were observed. No effect seemed to be produced on the bubbles on heating the crystals up to 54°C, so that the liquid was most probably water or an aqueous solution, and not carbonic acid.

Determination of the Optical Constants :—

The double refraction is positive. The plane of the optic axes is perpendicular to the plane of symmetry. The acute bisectrix makes with the vertical axis c' an angle of 34° approx. (in the acute angle β), *i.e.* it makes an angle of $11\frac{1}{2}°$ with the normal to c and an angle of 56° with the normal to a.

The angle of extinction on m measures 25° to the prism edge.

Optical axial angle (sodium light) :—

$$2E_a = 84°42'. \quad 2H_a = 51°29'. \quad 2H_o = 132°12'.$$

From which $2V = 50°49'$.

These determinations were made with plates cut at right angles to the 1st and 2nd mean lines. The oil used was oil of anise ($n = 1{\cdot}5569$ as determined by means of the total reflectometer). No dispersion of the axes was observed.

Refractive Indices (sodium light) :—

$$\alpha = 1{\cdot}5736, \ \beta = 1{\cdot}5759, \ \gamma = 1{\cdot}5877.$$

Double refraction, $\gamma - \alpha = {\cdot}0141$.

α and γ were determined by means of a prism cut symmetrically about the plane of symmetry, and with the refracting edge parallel to the acute bisectrix. β was determined by calculation from the optic axial angles in oil in the two plates, and the index of refraction of the oil.

The value of $2V$ calculated from the above values of α, β, γ, is 47°56′.

Measurements of the indices of refraction through the natural prism (m) gave the two values 1·5745 and 1·5889.

Owing to the small size of the transparent crystals, and the consequent difficulty in grinding down the plates and prisms by hand, the errors of orientation amounted in some cases to three or four degrees.

Experiment showed that the variation of the optical axial angle on change of temperature was scarcely appreciable. For a rise in temperature of 100° there appeared to be only a slight decrease in the angle of less than half a degree.

Chemical Characters :—

The mineral is infusible, and becomes opaque before the blowpipe. With cobalt nitrate it gives a blue colour. It yields much water in the closed tube. In fine powder it is slowly dissolved on digestion in hot concentrated hydrochloric acid.

Material for the quantitative analyses was carefully picked out under

the lens, and then separated as far as possible from quartz by means of methylene iodide. After the separation with methylene iodide the material was a second time picked out under the lens. It was found, however, to be impossible to completely remove the quartz from the augelite, for the very carefully selected material used in analysis I was found to contain 1·81 per cent. of silica, while the less carefully picked material used in the preliminary analysis II contained as much as 13·6 per cent. Blomstrand speaks of the difficulty of separating the quartz, and obtained in his analyses from 4 to 13 per cent. of silica. In the preliminary analysis II the water was determined by ignition, the phosphoric acid was separated by molybdate solution and reprecipitated by magnesia mixture, and the alumina was precipitated by ammonia and ammonium sulphide in the filtrate from the molybdate precipitate.

In analysis I the water was determined directly by absorption in a calcium chloride tube. A plug of sodium carbonate was placed in the mouth of the combustion tube in which the mineral was heated, to absorb any hydrofluoric acid which might be given off; but, on testing the sodium carbonate after the experiment, no fluorine was detected, and the increase in weight of the calcium chloride tube corresponded fairly closely with the loss in weight of the material. In this analysis the mineral was dissolved in hydrochloric acid, and the solution was divided into two portions, in one of which the alumina and the phosphoric acid were precipitated together by ammonia, while in the other the phosphoric acid was precipitated by molybdate solution, and finally weighed as pyrophosphate of magnesium.

The alumina was carefully tested for beryllium, but with negative results.

Result of Analyses :—

	I.	II.	III. (Blomstrand)	IV. (Theory)
P_2O_5	34·60	35·33	35·04	35·50
Al_2O_3	51·40	50·28	49·15	51·00
CaO	0·11[1]	0·90[1]	1·09	—
H_2O	13·77	13·93	12·85	13·50
Fe_2O_3	—	—	0·89	—
MnO	—	—	0·31	—
	99·88	100·44	99·33	100·00

[1] Most probably partly, if not wholly, derived from the reagents or from their action on the glass and porcelain vessels used in the analyses.

Weight of material used in analysis I = 0·8379 gr.
,, ,, in analysis II = 0·3164 gr.

No water was given off below 360°.

Under III is given the mean of Blomstrand's four analyses of the mineral from Westanå, and under IV the theoretical numbers required by the formula $2Al_2O_3.\ P_2O_5.\ 3H_2O$, or $AlPO_4.\ Al(OH)_3$.

The orthorhombic dufrenite has the analogous formula—

$$2Fe_2O_3.\ P_2O_5.\ 3H_2O.$$

The result of the analyses of the mineral from Machacamarca, together with the determination of the specific gravity and the observation of the three cleavage surfaces, showed that augelite was the only mineral to which it could be referred. Any doubt as to the absolute identity of the mineral from Bolivia with that from Sweden was at once set at rest when, through the kindness of Prof. Blomstrand, the Museum became possessed of a small specimen of the original augelite from Westanå; for the angles between the three cleavage surfaces were found by measurement to be, within a few minutes ($mm = 66°52'$, $mx = 77°33'$), the same as those between the corresponding faces on our crystals, and prism cleavage flakes from both minerals showed under the microscope with a $\frac{1}{12}$ immersion the same optical character, viz. the emergence of an optic axis just beyond the edge of the field.

Judging from the Museum specimens, augelite appears to be by no means a rare mineral at Machacamarca. That it has been so long overlooked may perhaps be accounted for by its having been mistaken for other minerals. Thus Sandberger (*Neues Jahrb.*, 1886, (1), p. 89) speaks of bournonite from this locality associated with barytes. We have found no barytes on any of the bournonite specimens from Machacamarca in the Museum collection, and it is just possible that the barytes to which Sandberger refers was really augelite, for the habit of the two minerals is somewhat similar.

Besides the augelite, on specimens from Machacamarca in the Museum collection we have noted the following minerals:—

Bournonite.—Grooved prisms with the forms *a b m c e n o u y* Ω[1]. The faces in the zone *n o u* [$11\bar{1}$] are sometimes large. The crystals are usually bright, but sometimes coated with melaconite, and at times much altered.

[1] The letters are those used in Dana's Mineralogy.

Iron Pyrites.—Symmetrically developed octahedra, usually very bright, but sometimes with a thin, dull, black coating (melaconite ?). One large isolated crystal is an icositetrahedron β {322} with small {111} planes. Another crystal shows the forms n {211} and p {221} besides the large octahedral faces.

Zinkenite.—Interlacing acicular crystals on the bournonite. A few needles are sometimes enclosed in the augelite. Sandberger (*loc. cit.*) notes the occurrence of guejarite on bournonite from Machacamarca. We have been unable to detect this rare mineral on our specimens : the acicular crystals on the bournonite on analysis always proved to be zinkenite.

Zinkenite, bournonite, pyrites, argentiferous galena, and tetrahedrite are mentioned by Damour[1] as occurring at Machacamarca.

Mispickel.—A few minute prisms on the pyrites, terminated by a very low pyramid and brachydome approximating to the basal plane.

Quartz.—Minute crystals covering the surface of the quartzose matrix on which the bournonite occurs.

Chalcedony.—Stained with oxide of iron.

Bleinierite.—Pseudomorphous after zinkenite.

Chalcanthite.—In the decomposition product from the bournonite.

Melaconite.—Thin dusty layer on the bournonite.

Anglesite.—In thin flakes, coating the bournonite crystals and lining crevices in them.

Blende.—Very rough, irregular, black crystals.

Copper Pyrites.—Massive.

We have given the above brief account of the mineral occurrences at Machacamarca since there appear to be very few references to the subject. Dana (*Mineralogy*, 6th Ed., p. 128) mentions Machacamarca as a locality for bournonite, and Domeyko (*Mineralojia*, 3rd Ed., p. 235) gives an analysis and short description of the mineral from this locality; but these, together with the two quoted above, are the only references we have been able to find respecting minerals from Machacamarca.

---

[1] F. de Castlenau, *Expédition dans les parties centrales de l'Amérique du Sud*, 1850–1. Vol. v. pp. 438–440.

A Note on Cone-in-Cone Structure.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., &c.

[Read November 20th, 1894.]

THE structure called cone-in-cone attracted my attention when I was working at certain forms of jointing and spherulitic structures in rocks,[1] and has been studied in a desultory fashion ever since. Moreover, the Museum of University College possesses some good specimens of cone in-cone obtained by the late Prof. Morris, and I received a present of others, which had been used by Mr. W. S. Gresley for his suggestive paper[2] when he left England for America. But though I formed some general conclusions on the subject, I abstained from writing, because I felt doubt concerning one point of importance, and had never seen a good example of cone-in-cone in the field. Both these obstacles were removed in the summer of 1892, so I venture to add a few words to the valuable paper of my friend, Prof. G. A. J. Cole,[3] not by way of criticism, but of confirmation and supplement. My conclusion, arrived at independently, is practically identical with his, and with that originally advocated by Dr. H. C. Sorby,[4] viz. that the structure is primarily and essentially due to crystallisation, which has started from a number of independent centres, either on or near to one surface of the bed, and has proceeded inwards, as spherulites attempted to form themselves, but produced sheaf-like growths from being crowded together. A similar process occurs, as I have already[5] described, in the devitrification of glass.

[1] *Quart. Jour. Geol. Soc.*, XXXII. (1876), p. 140. *Geol. Mag.*, 1877, p. 499.

[2] *Geol. Mag.*, 1887, p. 17. A very interesting paper by the same author appeared in the *Quart. Jour. Geol. Soc.* for Nov. 1894, p. 731, after this note had been sent to the Secretary of the Mineralogical Society. It brings forward additional evidence in support of the "crystallisation" theory, and practically anticipates some part of my note. But I leave it as written, since the conclusions were formed independently.

[3] *Min. Mag.* X. p. 136.

[4] *Brit. Assoc. Rep.*, 1859, pt. 2, p. 124.

[5] Presidential Address to the Geological Society, 1885. *Quart. Jour.* XLI. *Proc.* p. 95.

It is beautifully illustrated in a specimen which I obtained in 1892 from the upper part of the Wealden group in Sandown Bay, Isle of Wight. It formed part of the top "beef" bed (*f* of Prof. Judd's section[1]). This bed, above an inch in thickness, overlies a limestone "crowded with Cyrena and a few oysters." A slice cut so as to exhibit the upper bed and part of the lower shows the latter to be a somewhat "dirty" limestone containing numerous fragments of bivalves (probably for the most part *Cyrena*), with some of gasteropods (? *Paludina*), many valves of *Cyprides*, single and double, and mineral grains, chiefly quartz, the last being more plentiful in some bands than in others. From the top of this bed the crystalline "brushes" diverge upwards (the mineral being generally calcite, but perhaps sometimes ankerite[2]). The organic fragments, such as the convex sides of *Cyrenæ* and rather notably of *Cypris* valves, with occasionally (I think) a mineral grain, serve as *points d'appui* for the apices of these cones of diverging crystallites. When any two come together the line of junction is clearly indicated, especially when the nicols are crossed, and the structure of each sheaf of crystallites is rendered more conspicuous, but sometimes this line is made yet more distinct by a thin film of dark mud, probably extruded, as Prof. Cole suggests, during crystallisation. Fine lines, apparently cleavage planes, may be seen making angles of from 20° to 30° with the axis of the crystallites, and pointing downwards. Similar lines, pointing in the opposite direction, may be occasionally noticed. In the lower band the crystallites in the interior of the *Cypris* cases not unfrequently exhibit a radial structure, to which Dr. Sorby has already called attention. It may be noted also that the prismatic layers in the molluscan fragments are replaced, partially or often wholly, by granular calcite, but the nacreous layers are less affected. Probably the former were originally aragonite. This remarkably interesting and beautiful example confirms the evidence afforded by other specimens in my possession, similar to those described by Prof. Cole, and convinces me that he is right in attributing the cone-in-cone structure primarily to crystallisation.

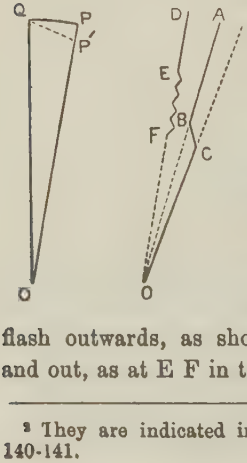
But we have also to account for the peculiar conical fracture which gives the name, and the fact that the surfaces of the cones are sometimes covered with approximately horizontal striations. The former may be thus explained. A half-spherulite may be regarded as consisting of acicular crystallites diverging from a centre and arranged symmetrically

[1] *Quart. Jour. Geol. Soc.* XXVII. (1871), p. 220.

[2] In the specimens from the Coal Measures which I have examined, the mineral is very often chalybite.

about a common axis, like a series of conical shells with a gradually increasing vertical angle. The rock itself is made up of a series of cones, representing portions of such groups of shells. Suppose it affected by a set of uniform strains due to contraction, such as would be produced in drying: if its material were perfectly uniform, it would break into vertical hexagonal prisms; but inasmuch as it has the structure just described, the surfaces of these cones will be surfaces of weakness (especially if they are parted here and there by films of extruded mud), and will determine the direction of fracture. Thus groups of cones will be developed, each consisting of one or more shells with a common apex and axis, and forming, at the outside of the bed, sets of concentric circular cracks generally two or three in number.

But the surface of rupture sometimes travels towards the axis, so as to produce a spiral crack on the outside. Of this I venture to offer the following explanation. Suppose P Q, two adjacent points in the circular base of one of these cones; let each be attracted towards the point O, its centre (corresponding with the end of the axis), and the conditions be such that fracture takes place at P slightly before it does at Q. On yielding let P move to P′. The effect of this is that Q is now also pulled slightly in the direction of Q P′, and has a tendency to move, not only along the radius O Q, but also slightly in the direction of P′. So the crack passes a little within the circle P Q and takes a spiral course. If the strains caused P to move in the opposite direction, the crack would travel outwards.



In regard to the other structure, the ribbed external surfaces, my view of their cause practically agrees with that put forward by Prof. Cole. I have already spoken of the tendency to form conical shells, and of the cleavage planes which exist in the rhombohedral carbonates (particularly in calcite) composing these masses. These planes also are surfaces of weakness, symmetrically disposed in consequence of the mode of growth of the aggregated crystallites.[2] Thus when a fracture occurs it may occasionally flash outwards, as shown at B C in the line A B C O, or turn in and out, as at E F in the line D E F. Both these forms may be found,

[2] They are indicated in the illustrations to Prof. Cole's paper, Figs. 1-3, pp. 140-141.

but the first is more usual. Sometimes these ribs are marked by carbonaceous crests or covering films; commonly they are not straight lines, but somewhat arched, with convexities towards the base of the cone. This may be the explanation: the development of the spherulite would probably include times of pause; these would produce surfaces of slight discontinuity in the form of spheres, and along these there would often be extrusion and deposition of carbonaceous material, which would make them more distinctly surfaces of weakness. When the axis of the cone of fracture was longer than a radius of the sphere (which would be, I think, the general tendency), these surfaces, in section, would arch upwards. The explanation, I admit, seems rather far-fetched, but after a good deal of consideration I am unable to devise a better.

Thus the cone-in-cone structure, as Professor Cole states, is primarily due to crystallisation, and is the result of a tendency to form "spherulites," though in a sedimentary instead of in an igneous rock. Its relation to the ordinary micro-columnar structure called "beef" is undoubtedly very close; the latter, indeed, may be regarded from the mathematician's point of view as the limit of the former, when the number of centres of independent crystallisation becomes infinite. But the developments of the cone-in-cone structure, its existence in short *as cone-in-cone*, is due to contraction subsequent to this crystallisation, and thus the mechanical cause is not less essential than the chemical one for its formation.

On the Occurrence of Delessite in Cantyre.

By Professor Heddle and Mr. Stuart Thomson.

[Read November 20th, 1894.]

DELESSITE is of much rarer occurrence in Scotland than saponite, and moreover it is by no means so characteristic in its appearances. Its modes of occurrence are much the same, only it is much less frequently the tenant of druses, affecting rather rents or fissures, and in these last it frequently goes to form what may be called a "composite vein." This may be filled for the most part with fibrous calcite, transversely disposed, and the reopening of the fissure is disclosed by the delessite, which, after lining one side of the vein for some distance, suddenly crosses the fibres of the calcite diagonally, and lies between it and the rock upon the opposite side.

Among a series of rocks lately forwarded to me by Mr. Gray, the industrious and observant curator of the admirably arranged little museum at Campbelltown, there was a specimen from Knockscalbert quarry which evidently was either saponite or delessite. The appearance and colour was certainly more that of the latter, but the rarity of that mineral did not leave much room for hope that it was so. The determination of the amount of water having shown that it was not saponite, Mr. Gray was requested to secure if possible a sufficiency for analysis.

This he speedily did, and he also furnished the following notes as to its occurrence.

"It is only found in the very centre of the quarry, a few feet from the bottom, and about 30 feet from the surface, that being the depth of the quarry. At present it shows over an area of about 3 yards. Where it does occur, every bit of rock is completely glazed with it; but the layer of glaze is very thin, as you will see by the hand-specimen which I send."

The physical properties are as follows :—

It has a dark green colour. The thickness of its veins is seldom over half-an-inch—generally it is in mere scales. It is everywhere bright

from the polish of slickenside movements. The direction of the slickenside striæ shows that even within a space of a few inches the rock fragments must have been moving in every direction. It is softer than the nail, and the colour of its streak is dark sap green. It does not break into fragments in water, nor when suddenly placed in the mouth.

The specific gravity was determined on three fragments ;

On 287·27 grains	=	2·638
On 158·5 ,,		2·578
On 226·2 ,,		2·609
Mean ...		2·608

The analysis yielded :—

	1st		2nd
Silica ...	34·69	...	34·37
Alumina ...	5·48	as $Al_2O_3Fe_2O_3$ 36·49	36·88
Ferric Oxide ...	10·82		
Ferrous Oxide	18·71		
Lime ...	2·49	...	2·16
Magnesia ...	12·21	...	12·00
Water ..	15·19		
	99·59		

7·29 of the water was given off at 100° C.

Although this composition differs considerably from that of other Scotch delessites, as previously determined by one of us, it yet accords fairly well with that of some foreign delessites.

The inclosing rock—a dense dolerite—is so little altered that it is not easy to say which constituent has yielded the mineral, but it appears to have resulted from an alteration of the augite.

OBITUARY.

Patrick Dudgeon, F.R.S.E.

ON the 9th of February, Mr. Dudgeon, of Cargen, one of the original members, indeed one of the founders of the Mineralogical Society, departed a useful and honoured life at the ripe age of seventy-seven.

A cultivator of several branches of science, he had, with his usual energy, been in the early part of the day tabulating for publication the *Meteorological Record*. In resting thereafter he was called to meet death face to face; and no one could more truly be said to have done so, as he was found in his chair, hands on knees, and looking before him with straightforward gaze.

All the district in his neighbourhood mourns the loss of a typical Scottish gentleman, a kind and considerate landlord, a cultured and honoured citizen. Friends of his own standing mourn features of character which they know can never be replaced to them.

Born in Mid-Lothian, Mr. Dudgeon was educated at the Edinburgh Academy—an institution of which Sir Walter Scott was one of the founders, and to which he gave the tutor of his own boys as Rector, the Archdeacon Williams. Sir Walter seems to have imbued this school in an abiding manner with his own love of nature; as it has often been remarked that it produced more scientists and naturalists than any similar institution in the north.

Mr. Dudgeon resided in China for some sixteen years, about the time when Japan was first opened to Europeans; and it was from these islands, as well as from China itself, that he gleaned the specimens of his first mineralogical collection, namely of minerals embedded in rock crystal.

This collection, altogether unrivalled elsewhere, now fills a case in the Edinburgh Museum of Science and Art; and it used to be a source of great pride to Mr. Dudgeon to assert that there were only two specimens in the British Museum which were worthy to be placed beside it.

Shortly after his return to this country in 1850, Mr. Dudgeon became

associated with Professor Heddle, and they were ever after in every way associated in mineral exploitation, mineral analyses, and mineral collecting.

One of their first enterprises was a Survey of the Färoe Islands. For this a vessel was specially chartered and fitted, quarrymen engaged, and the country searched for the greater part of five months. Similar excursions by yacht followed in the Shetlands, the Orkneys, and part of the Hebrides.

The results, as regards the size and excellence of the specimens collected, being quite commensurate with the scale upon which these surveys were conducted, Mr. Dudgeon ultimately presented the whole of his Scotch collection to the Nation, to form the nucleus of a collection of Scottish minerals.

Shortly thereafter he enriched the general collection of minerals in the Edinburgh Museum by the gift of his general collection, but his sole interest lay in the enriching of the Scottish collection; and his delight was unbounded when he found that the larger collection of his life-long associate was to rest beside and be incorporated with his own. The chief palliative of that associate's grief at his irreparable loss lies in the thought that each day's labour brings him nearer the completion of that which is to stand as an abiding monument to the *originator of the collection of Scottish minerals.*

M. F. H.

NOTES AND COMMENTS.

THE Society has lost one of its corresponding members in the person of Dr. Frederik Johnstrup, Professor of Mineralogy and Geology at Copenhagen, who died on the 31st December at the age of 76. He was appointed to the Chair in 1866, and published numerous memoirs relating to the Geology of Denmark; his well-known researches on the Geology of Greenland were commenced in the year 1876, and in 1888 he was appointed to the Directorship of the Geological Survey of Denmark.

Among recent changes in the Mineralogical world it may be noted that Professor Chrustchoff has been called from Kharkov to the Chair at the Military Academy of St. Petersburg, and that Dr. J. S. Talmage has been elected to a newly founded Professorship of Geology in the University of Utah; while death has removed the distinguished Mineralogist and Crystallographer, Professor C. v. Haushofer, who since 1889 had been director of the Technische Hochschule at Munich.

An interesting discovery has been announced by Professor Krenner, of Budapest, who describes a mineral containing no less than 59·5 per cent. of thallium, to which he has given the name Lorandite. He finds the mineral to have the formula $TlAsS_2$; it occurs as red tabular or prismatic crystals belonging to the mono-symmetric system, and is found on realgar at Allchar in Macedonia.

We have received from Messrs. George Philip and Son a geological map of Western Australia, executed by Mr. H. P. Woodward, the Government Geologist, which can be confidently recommended to all who desire a clear map of that interesting colony. The numerous gold fields

to which public attention has been so strenuously directed during the last year are well shown, and the routes of various explorers in the less known parts of the country are clearly indicated. The scale is about 50 miles to the inch.

A Catalogue sent by Messrs. G. L. English, of New York, the enterprising firm of mineral dealers, makes it evident that the interest in minerals is by no means waning in the United States: the Catalogue extends to 124 pages, and with copious figures and descriptions practically constitutes a brief handbook; the very full list of recent acquisitions seems to contain most of the minerals of interest which have been lately reported from various parts of the world.

REVIEW.

Guide to the Collection of Building Materials in the Natural History Museum of Vienna. [Führer durch die Baumaterial-Sammlung des k. k. Naturhistorischen Hofmuseums.] By Felix Karrer; with a Preface by the Editor, Dr. Aristides Brezina, Director of the Mineralogical Department. Small 8vo, 302 pages, with 40 illustrations. Vienna, 1892.

This guide is the first of the special catalogues which it is the intention of Dr. Brezina to issue for the various collections in the Mineralogical Department of the Natural History Museum in Vienna.

In the introduction, definitions and brief descriptions of the principal rock types are given, and the general plan of arrangement of the specimens is explained. The arrangement is in the first place a geographical one; each country, and in the case of Austria-Hungary each of the principal towns, is represented by a special collection: in each of these collections the various kinds of building material are distributed into groups according to the different uses to which they are applied, *e.g.* road metal, paving stones, building stones, decorative stones, roofing slates, artificial stones, etc.: in each of these groups the species are arranged according to their petrographical relations, and in each petrographical division according to their geological age.

A collection of building materials thus arranged, besides being of great practical value to the architect and builder, and affording considerable interest to the geologist, should also have its attractions for the general public, to whom it gives an opportunity of learning something of the nature and variety of the rocks and minerals employed in the construction of the towns in which they live. A small collection of this kind, to illustrate the several kinds of building material used in the town in which it is situated, would be a useful feature in all local museums. In the Vienna collection we notice that England is very poorly represented by a few specimens only of ornamental and artificial stones.

The guide is illustrated by photo-types of public buildings of many of the principal cities of Europe, with descriptions of the different kinds of stone used in their construction.

Abstracts.

Blue soda-bearing amphibole from California. C. Palache describes a new amphibole mineral from the crystalline schists near Berkeley, California (*Bull. Geol. Dep. Univ. Cal.*, Vol. I. p. 181, 1894). It occurs in little prisms embedded in clear, mostly untwinned, albite, which is the main constituent of the rock. A clinopinacoidal section gives the extinction angle ($c\ a$) 13°, in front. The pleochroism is very strong: a, sky-blue to dark blue; β, reddish to purplish violet; γ, yellowish brown to greenish yellow. In certain veins which traverse the rock, fracturing the amphibole crystals, the latter show a secondary outgrowth of fibrous green actinolite giving the extinction-angle ($c\ \gamma$) 17°—18°, behind. The blue mineral has a specific gravity 3·126—3·16, and gives the composition

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	Total
55·02	4·75	10·91	9·45	tr.	9·30	2·38	7·62	0·27	99·70

It thus stands in some respects midway between glaucophane and riebeckite. In optical characters it closely resembles the mineral described by Whitman Cross from Colorado, which was not analysed (see *Min. Mag.* Vol. IX. p. 249), and the author proposes for it the name "Crossite."

A. H.

A new anorthoclase-augite-rock from Vulcano. W. H. Hobbs describes, under the name "volcanite," a rock ejected in the form of bombs during the eruption of Vulcano, in the Lipari Islands, in 1888. The bulk-analysis of the rock is given in column I. (by Kahlenberg), and corresponds rather closely with that of the dacites, but the mineralogical constitution is quite different. There is a vitrophyric ground-mass enclosing large crystals of felspar, augite, and rarely olivine (?). Most of the felspar shows no twin-striation, and is found to be anorthoclase (analysis II. by Scoular). Subordinate andesine also occurs. The augite is green in slices: its specific gravity is 3·2834, and its composition is shown under III. (by Urban). The ground-mass of the rock is a glassy base full of minute felspar laths and crystallites of augite: its analysis is given by IV. (Kahlenberg). There are holocrystalline patches supposed to represent the relics of inclusions of dolerite. Less common is an acid

	I.	II.	III.	IV.	V.
SiO_2	66·99	60·01	47·60	67·55	74·57
Al_2O_3	17·56	20·12	4·66	18·04	13·09
Fe_2O_3	1·41	2·82	—	1·18	—
FeO	3·39	not det.	12·73	3·15	—
MnO	tr.	—	tr.	tr.	—
MgO	0·93	0·23	14·56	0·74	—
CaO	4·25	5·15	18·06	3·03	1·32
Na_2O	3·35	6·43	1·50	4·39	
K_2O	0·34	3·67	—	0·11	
H_2O	1·53	0·77	0·50	1·06	
P_2O_5	tr.	—	—	—	
	99·75	99·20	99·61	99·25	

inclusion consisting of a crystalline aggregate of felspar and quartz: a partial analysis of this (by Urban) gave the result V. (*Zeits. deuts. geol. Ges.* Vol. XLV. p. 578, 1894). A. H.

Leucite-bearing rocks in Celebes. Humboldt's statement that leucite was a mineral known only in Europe was first challenged by Vogelsang's discovery of a leucite-basalt in the island of Bawean, north of Java, and other observers have since recorded various leucitic rocks from Java itself. To these A. Wichmann has now added a number of occurrences in the south-western peninsula of Celebes (*Natuurkundig Tijdschr. Ned. Ind.* Part LIII. p. 315, 1893). From Parang-Lowe, near Macassar, he describes a bedded tuff composed largely of fragments of leucite-tephrite, containing crystals of felspar and leucite in a brown base. From the Pangkadjéné river comes a dark compact leucite-basalt with porphyritic crystals of green augite, and partly serpentinised olivine in a ground-mass of little leucite crystals, augite-microlites, octahedra of magnetite, and dark brown globulitic glass. A leucitite from the Masépé river shows abundant leucite in good crystals as a constituent of the otherwise much decomposed ground-mass: augite occurs porphyritically. Another type, from Tempé, has relatively large porphyritic leucites and augites in a microcrystalline ground of leucite, augite, sanidine, magnetite, and apatite. Here the presence of sanidine marks an approach to the characters of leucitophyre. Lastly, from the Walannaë river are described a leucite-basalt with porphyritic augite and leucite in a ground of leucite, augite, olivine, melilite, nepheline, and magnetite, and two

varieties of leucitite. It is remarkable that the lavas of the Celebes volcanoes belong in general to the widely different type of augite-andesites.

A. H.

The Constitution of the Zeolites. (F. W. Clarke, *Am. J. Sc. XLVIII.* p. 187, 1894). In this preliminary paper the author considers the zeolites as being substitution derivatives of simple normal salts, such as $Al_4(SiO_4)_3$, $Al_4(Si_3O_8)_3$ etc., in the same way as he has previously considered the micas, chlorites, etc. The relation existing between the felspars and the zeolites is shown by anorthite and albite also being derivatives of the same two salts respectively, and by such facts as that many zeolites are derived from felspars, and that many on fusion yield anorthite.

Temporarily regarding all the water as water of crystallisation, and representing the mutually replaceable groups SiO_4 and Si_3O_8 by X, most zeolites fall into one of the two groups:

1. $Al_6X_6R'_6$, n aq. + $Al_3X_3R'_3$, n aq.
2. $Al_4X_6R'_{12}$, n aq. + $Al_2X_3R'_6$, n aq.

as is shown in the following table:—

	First Group.	
Thomsonite	...	$Al_6(SiO_4)_6(CaNa_2)_3 \cdot 7H_2O$
Gismondite	...	$Al_6(SiO_4)_6(CaK_2)_3 \cdot 12H_2O$
Phillipsite	...	$Al_6X_6CaR'_4 \cdot 15H_2O$
Levynite	...	$Al_5X_6Ca_3 \cdot 15H_2O$
Chabazite	from to	$Al_6X_6Ca_3 \cdot 18H_2O$ to $Al_3X_3Na_3 \cdot 9H_2O$
Gmelinite	...	$Al_3X_3Na_3 \cdot 9H_2O$
Hydronephelite	...	$Al_3(SiO_4)_3Na_2H \cdot 3H_2O$
Offretite	...	$Al_3X_3R'_3 \cdot 8H_2O$
	Second Group.	
Foresite	...	$Al_4(SiO_4)_6CaH_{10} \cdot H_2O$
Scolecite	...	$Al_4(SiO_4)_6Ca_2H_8 \cdot 2H_2O$
Laumontite	...	$Al_4X_6Ca_2H_8 \cdot 4H_2O$
Heulandite	...	$Al_4X_6Ca_2H_8 \cdot 6H_2O$
Epistilbite	...	$Al_4X_6Ca_2H_8 \cdot 6H_2O$
Stilbite	...	$Al_4X_6Ca_2H_8 \cdot 8H_2O$
Faujasite	...	$Al_4X_6Na_2CaH_8 \cdot 15H_2O$
Natrolite	...	$Al_2(SiO_4)_3Na_2H_4$

A few details regarding each species are given; thus *thomsonite* has a formula equivalent to anorthite plus water; taking account of the constitutional water, the formula is written—

$$Al_4(SiO_4)_6Ca_3(AlH_2O_3)_2H_4 \cdot 3H_2O.$$

Here the group—$Al{=}(OH)_2+H_2$ replaces Al. The excess of silica in "mesole" is accounted for by small admixtures of Si_3O_8.

Other zeolites do not fall into these two groups, thus: ptilolite and mordenite are salts of $H_2Si_2O_5$; analcite and leucite, being closely allied, are represented by formulæ of the same type.

Leucite. Analcite.

$$Al\begin{cases}SiO_3\\SiO_3-K\end{cases} \qquad Al\begin{cases}SiO_3\\SiO_3-Na\end{cases}+H_2O$$

The related minerals okenite, gyrolite and apophyllite are considered as salts of $H_6Si_2O_7$ analogous in structure; apophyllite being written:—

$$Ca\begin{cases}Si_2O_7\cdot H_4(CaOH)\\Si_2O_7\cdot H_4\\Si_2O_7\cdot H_4(CaOH)\end{cases}$$

Here potassium partly replaces the group—Ca—OH, and fluorine the hydroxyl. L. J. S.

Formation of Ore Deposits by differentiation processes in basic magmas. (J. H. L. Vogt, *Zeitsch. f. prakt. Geologie*, pp. 4, 125, and 257, 1893).

In the *Geol. Mag.* for 1892 (p. 82) Teall gives a review of a former paper by Vogt on this subject.

The process of differentiation is well illustrated in dykes with basic margins, *e.g.* the Huk dyke in the Christiania district, which has a centre of mica-syenite-porphyry and the margins of kersantite. The ore deposits may be divided into two groups—I. those with oxides, and II. those with sulphides.

I. The separation of oxides (ilmenite and titaniferous magnetite). —Examples of this are the dykes and veins of ilmenite-norite and ilmenite in the labradorite rock and norites of the Ekersund-Soggendal district (South Norway); here there is a continuous series from labradorite rock (with 2 per cent. of ilmenite and 94 per cent. of labradorite), through ilmenite-norite (with usually 40 per cent. of ilmenite), to ilmenite masses (with 99 per cent. of ilmenite and 1 per cent. of labradorite). At Taberg (South Sweden) there is a gradual passage from olivine-hyperite to a magnetite-olivine-rock, and near Kragerö (Norway) are passages from

olivine-hyperite into an ilmenite-enstatite-rock. In Brazil pyroxene-bearing nephelinite passes gradually into nepheline- and magnetite-pyroxenite.

These concentrations occur in the centre of the eruptive masses, and consist of minerals of the first and second consolidation periods, *i.e.* ilmenite, titaniferous magnetite, and ferro-magnesian silicates. Other heavy metals are only rarely observed, but in the Brazilian deposits are Nb, Ta, and Zr (in baddeleyite).

II. Separation of sulphides (nickel-bearing pyrrhotine and pyrites, rarely with pentlandite, millerite and polydymite). Pyrrhotine, the most important, usually contains 3—4·5 per cent. of Ni+Co, there being 6—8 times as much Ni as Co; the presence of these is not due to the mechanical mixture of pentlandite &c. with the pyrrhotine, but to the isomorphous replacement of the iron. Copper pyrites with 0·5 per cent. of Ni+Co, crystals of pyrites rich in cobalt, and ilmenite also occur, but other minerals are rare; sperrylite is, however, occasionally present in the deposits of Sudbury (Canada).

In Norway and Sweden the deposits occur in hyperites, norites, labradorite-rock, gabbros, &c. The ores are usually strictly confined to the margins of the masses; sometimes there is a gradual passage from gabbro, &c., through pyrrhotine-gabbro and norite to pure ore, at other times there is a sharp junction.

As ferro-magnesian silicates have not been concentrated along with the sulphides, the pyrrhotine-norites, &c., may be considered as norites, &c., with 1—99 per cent. of pyrrhotine; the silicates being embedded porphyritically in the sulphides.

III. A third kind of separation in eruptive rocks is the *separation of metals*. Here are two groups—1, nickel and iron; and 2, platinum and osmiridium. The Disko iron contains Ni, Co, and Cu in much the same proportions as the pyrrhotine deposits. Platinum (with much Fe, Cu, &c., and little Os and Ir) and the Disko iron (poor in Ni) are early stages of the separation processes, while osmiridium and awaruite (rich in Ni) are more advanced stages.

Laws of differentiation of eruptive magmas. There may be three ways for concentration to take place:

1. Mechanical separation of already formed minerals in the mother liquor.

2. Minerals may be first formed and concentrated, and then reabsorbed in the mother liquor.

3. Concentration by diffusion of fluid molecules or ions.

As the minerals in the ore deposits have been formed *in situ* and are not corroded, only (3) will apply. Magmas may be compared to salt solutions; ores, accessory minerals, and ferro-magnesian silicates being held in solution are therefore the materials which will be concentrated. Temperature differences and gravity have the effect of altering the homogeneity of salt solutions. In an enclosed magma basin, on account of cooling, there will be concentration in the upper portions (Soret's principle), while gravity will give rise to a concentration at the bottom of the basin (Gouy and Chapéron's principle).

The oxide and sulphide separations only occur in basic plutonic rocks, never in volcanic rocks, as the separation processes obviously depend on the time, and never in acid rocks on account of their greater viscosity and their poverty in heavy metals. The sulphide separations, which almost always occur at the borders of the eruptive masses, are easily explained by Soret's principle. On the other hand, the oxide separations, which do not occur at the borders, are not due to differentiation processes arising from temperature differences, but may have been brought about by the influence of gravity, and perhaps also magnetic and electrical forces.

The laws of differentiation are thus very complicated, depending on a whole series of factors, viz. the chemical relations of the fluid molecules, influence of osmotic pressure, gravity, and perhaps also magnetic and electrical forces; properties of solutions, diffusion, viscosity, melting points, the presence of mineralising agents, besides probably many others.

L. J. S.

Canfieldite and Argyrodite (S. L. Penfield, *Am. J. Sc.* XLVII., 1894, p. 451).—The germanium mineral recently described by the author as canfieldite has been shown to be identical with the previously described argyrodite, which was found afterwards to be cubic, instead of oblique as at first stated (Abstract, p. 336, Vol. X.). In the present paper the isomorphous tin compound, which comes from La Paz, Bolivia, is described. The mineral occurs in octahedra modified by dodecahedral planes, and is almost identical with argyrodite in its physical properties. The lustre is brilliant metallic, and the colour is black with the same bluish to purplish tone as argyrodite. H = $2\frac{1}{2}-3$: sp. gr. = 6·276. Analysis gave:

S	16·22
Sn	6·94
Ge	1·82
Ag	74·10
Zn and Fe ...	·21
	99·29

This gives the formula $4Ag_2S\cdot(Sn,Ge)S_2$ with Sn : Ge=12 : 5. For this new sulpho-stannate the name canfieldite is now proposed; argyrodite being the isomorphous germanium compound, which partly replaces the canfieldite in the above analysis. As described by Weisbach, the Freiberg argyrodite is hemihedral, but the Bolivian argyrodite and canfieldite are apparently holohedral, with, however, indications of twinning. The only previously known sulpho-stannates are—stannite, franckeite, and the doubtful plumbostannite. Franckeite has recently been described by Stelzner, and in it Winkler has detected a small amount of germanium (*Neues Jahrb.* 1893, II., p. 114). L. J. S.

The Chemical Composition and Related Physical Properties of Topaz (S. L. Penfield and J. C. Minor, Jr., *Am. J.Sc. XLVII.* p. 387, 1894).—The formula usually accepted is that of Groth $[Al(F_2,O)]\ AlSiO_4$, corresponding to an isomorphous mixture of $(AlF_2)AlSiO_4$ with the andalusite molecule $(AlO)AlSiO_4$. Rammelsberg suggests a mixture of Al_2SiO_5 and Al_2SiF_{10} in the proportion of 5:1. It has been previously shown by one of the present authors that hydroxyl frequently replaces fluorine, and it is doubtful if bivalent oxygen ever plays this *rôle;* in confirmation of this it has been found that the variations which topaz shows, both in chemical composition and physical properties, are the result of an isomorphous replacement of fluorine by hydroxyl, and that the formula is $[Al(F,OH)_2]_2SiO_4$ or $[Al(F,OH)_2]\,AlSiO_4$. In the analyses the water was expelled by fusing at an intense heat with sodium carbonate, and collected in a sulphuric acid tube. The fluorine was determined by fusing the mineral with quartz and sodium and potassium carbonates, and precipitating as calcium fluoride. The SiO_2 in six complete analyses varied from 31·93 to 32·82 per cent. and the Al_2O_3 from 55·41 to 56·61 per cent.; while the ratios were almost exactly $SiO_2:Al_2O_3:F+OH=1:1:2$. In the following table it is seen that the optic axial angle for yellow light and the density decrease as the fluorine is replaced by hydroxyl:—

	2E.	Sp. gr.	Fluorine.	Water.
Zacatecas, Mexico	126°28′	3·574	—	0·18
Thomas Range, Utah	125°53′	3·565	20·37	0·19
Nathrop, Colorado	125°51′	3·567	20·42	0·29
Pike's Peak, Colorado	122°42′	3·567	—	0·48
Tenagari, Japan	120°59′	3·565	19·50	0·57
Adun Chalon, Siberia	118°46′	3·562	19·24	0·58
San Luis, Mexico	118°17′	3·575	19·53	0·80
Schneckenstein, Saxony	114°28′	3·555	18·50	0·93
Stoneham, Maine	113°50′	3·560	18·56	0·98
Minas Geraes, Brazil	84°28′	3·532	15·48	2·45
,, ,, ,,	—	3·528	—	2·50

It is evident, therefore, that the topaz from Durango, Mexico, mentioned by Des Cloizeaux as giving the largest value of $2E=129°30'$, must approach to the pure fluorine compound $(AlF)_2SiO_4$, while that from Mugla, Asia Minor, giving the smallest value of $2E=71°32'$, must be the richest in hydroxyl of any topaz yet examined. The indices of refraction show a progressive change along with the variations of 2E, increasing while the double refraction decreases as hydroxyl replaces fluorine. The crystallographic axes are also affected by the isomorphous replacement.

	2E	α	β	γ	$\gamma-\alpha$	$021 : 02\bar{1}$
Utah	126°24′	1·6072	1·6104	1·6176	0·0104	87°19′
Brazil	86°21′	1·62936	1·63077	1·63747	0·00811	86°55½′

Optical anomalies were only observed in Brazilian crystals, in sections of which an inner rhomb and outer segments are seen, indicating variations in the refractive indices, and the existence of an inner core or older crystal surrounded by a later growth. Des Cloizeaux found that the central and outer segments of such a zonal crystal gave different values for 2E. As the physical properties vary with the composition, such compound crystals must be subject to mechanical strains, giving rise to the optical anomalies.

Similar variations in the physical properties brought about by the partial substitution of fluorine by hydroxyl have been also observed in herderite (Penfield, *Am. J. Sc.* Vol. XLVII. p. 329, 1894), in which are known the pure hydroxyl compound, hydro-herderite $Ca(BeOH)PO_4$, and the hydro-fluor-herderite $Ca[Be(OH,F)]PO_4$ with OH:F=3:2. With topaz the nearly pure fluorine extreme is known $(AlF)_2SiO_4$, and the hydro-fluor topaz from Brazil $[Al(F,OH)]_2SiO_4$ with F:OH=3:1. In both an increase in the hydroxyl is accompanied by a decrease in density and in the optic axial angle, and an increase in the indices of refraction.

L. J. S.

The Formation of Sandstone Concretions (G. P. Merrill, *Proc. U.S. National Museum, XVII.* p. 87).—The loose sandy beds of the Potomac division of the cretaceous, exposed in reservoir excavations in Washington, D.C., contain numerous irregular nodular masses of siliceous sand and marcasite. On weathering, the marcasite at the surface gives rise mainly to sulphates; but when buried in the sand, the partial weathering causes separation of ferric oxide, which segregates in a narrow zone about the nodule, cementing together the sand and giving rise to a hard coating; the sand mixed with the marcasite being left partially filling the cavity of

these "box-stones." The marcasite may have originated by the reduction of ferrous sulphate solution by the associated lignite. L. J. S.

Penfieldite (S. L. Penfield, *Am. J. Sc.*, XLVIII. 1894, p. 114).—This mineral from Laurium, Greece, described by Genth (*Am. J. Sc.*, p. 260, 1892) as having the composition $PbO \cdot 2PbCl_2$, is now described crystallographically. The crystals are long hexagonal prisms with the basal plane, and a pyramid of the second order, p $(52\bar{1})$; $c:p$ is given as 41°53′, from which $a:c = 1 : 0{\cdot}8967$. Some crystals show steep pyramids of the first order, giving rise to horizontal striations on the prism faces, and causing the crystals to taper to a point. The double refraction is strong and positive. L. J. S.

The cleavage and parting Planes of Oligoclase and Albite, (S. L. Penfield, *Am. J. Sc.*, XLVIII. p. 115, 1894).—Some massive specimens of clear glassy felspar from Hawk mica mine, Bakersville, Mitchell Co., N.C., shown by analysis to be oligoclase with $3{\cdot}6\,Ab + 1An$, exhibit the perfect basal cleavage, together with an imperfect cleavage or parting parallel to the pyramid $(\bar{1}2\bar{1})$, but the (010) cleavage and the polysynthetic twin lamellæ are absent. As this second abnormal cleavage had previously been taken to be (010) the mineral was supposed to have abnormal optical properties (as regards extinction and position of the optic axes). The indices $(\bar{1}2\bar{1})$ were fixed by the angle of about 88° for $001 : \bar{1}2\bar{1}$ (calc. 87°25′), and the extinction on the basal plane of 38°—40° with reference to the edge $001/\bar{1}2\bar{1}$. When the specimens are broken in the direction of (010) they only present curved surfaces of a conchoidal fracture. Other specimens from the same locality present the normal cleavage and polysynthetic twinning, and in these it is easy to produce the (010) cleavage; it is therefore suggested that this cleavage may possibly be the result of separation along the plane of twinning.

A crystal of albite from Amelia, Virginia, on being broken, gave fragments bounded by the basal plane and by surfaces parallel to the prism m (110), and the pyramid o $(\bar{1}\bar{1}1)$; the latter having the appearance of perfect cleavages, but being in reality only partings as they cannot be produced indefinitely. These partings are readily produced by pressure in the direction of the b axis. The parting (110) is produced on throwing heated albite into water.

The cohesion relations of the plagioclase felspars may thus show considerable variations. The basal cleavage is always perfect; that parallel

to *b* (010) is usually distinct, except sometimes when the polysynthetic twin lamellæ are absent, while under certain conditions of pressure or tension partings parallel to *m* (110), *o* ($1\bar{1}1$), and ($\bar{1}21$) may occur.

L. J. S.

The Identity of Hydrofranklinite and Chalcophanite (S L. Penfield and D. A. Kreider, *Am J. Sc.* XLVIII. p. 141, 1894).—Hydrofranklinite was described by W. T. Rœpper as a hydrous oxide of iron, zinc and manganese, crystallising in brilliant, iron-black octahedra, with perfect octahedral cleavage, and occurring on manganese ore at Sterling Hill, near Ogdensburg, New Jersey. The analysis by the present authors (a previous one not having been made) agrees closely with the formula $RO{\cdot}2MnO_2{\cdot}2H_2O$, where R=Fe and Zn in the proportion of 8:13. It is also shown that the apparent octahedron consists really of a rhombohedron with the basal plane, and that the perfect cleavage is basal. Sp. gr. 4·012. The mineral is thus the same as G. E. Moore's chalcophanite, from the same locality, in which, however, R=Zn and Mn, and the crystals are tabular in habit.

In separating the material for analysis, the fused double nitrate of silver and thallium, as suggested by *Retgers*, was used. This double salt, which contains the two simple salts in equal molecular proportions, fuses at 75°C, has a specific gravity of about 5, and is miscible in all proportions with water, the melting point falling to 50° or 60° as water is added. In the paper an improved apparatus is described, consisting of a test-tube, into a hole in the bottom of which a rod fits, acting as a plug, to be raised to allow the escape of the denser part of the separated material.

L. J. S.

Large Fluid Enclosures in Gypsum from Sicily (Hy. Sjögren, *Bull. Geol. Inst. Upsala, Vol. I.* p. 277, 1893).—Associated with sulphur and aragonite at Cianciana, Girgenti, are large, transparent, lenticular crystals of gypsum (0·3 m. long), with irregular, branching, fluid enclosures, 20—30 mm. in extent; others are flat, extending along the best cleavage. All the enclosures show bubbles, which do not diminish in size when the crystal is slightly heated. On boring to the largest cavity, 3 cc. of a neutral liquid were obtained; sulphuretted hydrogen, at not a very great pressure, escaping from the cavity. The water contained 4·02 per cent. of saline matter, which had the composition:—

K_2SO_4	...	...	3·7 per cent.
Na_2SO_4	...	...	11·4 ,,
$CaSO_4$	...	...	9·7 ,,
NaCl	...	...	66·2 ,,
$MgCl_2$	...	...	9·0 ,,

The solution is thus very similar in composition to sea water, and to the water of several sulphurous springs (*e. g.* the Kaiserquelle at Aix-la-Chapelle).

These enclosures may throw some light on the origin of the sulphur, to explain which two views have been advanced. According to one it has originated by the reduction of gypsum by organic matter, in isolated lagoons, where the less soluble salts have been precipitated. The mother-liquor of such a lagoon does not however correspond in composition to that of the enclosure examined. The other view is that the sulphur and gypsum have been deposited by springs containing sulphuretted hydrogen, and in support of this it is seen that the composition of Sicilian spring-waters of the present day agrees with that of the enclosure. L. J. S.

Artificial Production of Anhydrite (R. Brauns, *Neues Jahrb. f. Min.* II., p. 257, 1894).—The experiments which have hitherto been successful in the artificial production of anhydrite, have not been made under the same conditions that have obviously existed in nature. It has been formed by fusing together calcium sulphate and chloride, but the volcanic occurrences of the mineral are rare (Vesuvius); the methods in which gypsum is heated in a sealed tube with chlorides, or digested with hot sodium chloride solution, could not be the same as those which have taken place in the deposition of anhydrite from concentrated sea water.

In the author's experiments, a large drop of a saturated solution of sodium and potassium chlorides is placed on a microscope slide, at its side a drop of calcium chloride solution, and opposite this a drop of magnesium sulphate solution, the two drops are then brought into contact by a narrow path and allowed to evaporate. As diffusion takes place between the drops anhydrite is deposited, and here and there gypsum, while the alkaline chlorides near the calcium chloride drop separate out as octahedra or cubo-octahedra (this form being due to the influence of the calcium and magnesium chlorides). The clear, transparent anhydrite crystals have the form of short prisms with the ends rounded, and average 0·025 mm. in breadth and 0·035 in length, the largest having twice these dimensions. They are often united together in the middle, and some-

times form small globules, behaving in polarised light as radially-fibrous aggregates. The smaller axis of optical elasticity is parallel to the length of the prism. On removing the salt crystals and adding a little water, the anhydrite crystals are immediately corroded and gradually disappear, and, on allowing to evaporate, gypsum, and not anhydrite, crystals are formed. In case the amount of water added is not enough to completely dissolve the anhydrite, gypsum crystals are deposited around the corroded forms; or sometimes when the gypsum crystals do not grow on the surface of the anhydrite, but near to it, the former substance can be seen to grow at the expense of the latter. Calcium sulphate is therefore one of those substances which crystallise in compounds poor in water from saline solutions. A similar instance is seen with magnesium sulphate, which crystallises as kieserite ($MgSO_4 \cdot H_2O$) instead of as epsomite ($MgSO_4 \cdot 7H_2O$), when the solution contains magnesium chloride: and sodium sulphate from a pure aqueous solution separates as glauberite ($Na_2SO_4 \cdot 10H_2O$), but in the presence of sodium chloride as thenardite (Na_2SO_4). In nature, anhydrite, kieserite, and thenardite crystallise from saline solutions, so that the view is well grounded that salts in solution hinder the separation of compounds rich in water, having the same effect as an increase in temperature. L. J. S.

Occurrence of Nepheline Syenite in the Township of Dungannon, Hastings Co., Ontario (F. D. Adams, *Am. J. Sc. XLVIII.* p. 10, 1894).—This large area (extending for seven miles in one direction) of nepheline syenite is the first that has been found in the Laurentian of Canada: it is partly bordered by crystalline limestone, and is intimately associated with a fine-grained biotite granite (aplite). The rock has a hypidiomorphic granular structure, and is frequently massive but sometimes distinctly foliated. The texture is usually coarse, sometimes very coarse, with nepheline individuals two-and-a-half feet across. The essential constituents are nepheline and plagioclase, with either a little brown mica or dark green hornblende; the accessories are scapolite and calcite, and less abundantly garnet, zircon, sodalite, magnetite, pyrites, and apatite. The clear, colourless nepheline, which has a vitreous rather than a greasy lustre, is the most important constituent. The plagioclase, which is albite, is seldom very abundant, but is in most cases present. There are two varieties of hornblende, as seen by the extinctions, the optic axial angle, pleochroism, and composition, one being common hornblende and the other allied to arfvedsonite. Both contain considerable amounts of soda,

Scapolite is present as an original constituent in clear, colourless grains. Since the rock is fresh, the calcite must also be original, as is also seen by its mode of occurrence in well defined, more or less rounded, individuals, with, and often enclosed in, the other minerals. Bright blue sodalite is present as scattered grains or strings, and at places in large masses. It is associated with strings of iron ores, and is traversed by cracks filled with reddish secondary orthoclase.

The author defines a nepheline syenite as a rock composed essentially of nepheline and an alkali felspar, instead of one composed of nepheline and orthoclase, as the present rock differs greatly in composition from typical specimens of theralite. This Dungannon rock approaches the nepheline syenite of Litchfield, Maine ("Litchfieldite"), which has orthoclase as well as albite, and further contains neither augite nor sphene (*cf.* Abstract, Vol. X. p. 345). In places where the rock consists only of nepheline with a little hornblende or mica, it is really an ijolite rather than a nepheline syenite.

In an accompanying paper by B. J. Harrington (p. 16) analyses and descriptions are given of the nepheline, sodalite, and the orthoclase in the sodalite. L. J. S.

CONTENTS OF No. 49.

	PAGE
A Chemical Study of some Native Arsenates and Phosphates. By A. H. Church, M.A., F.R.S.	1
A Basic Ferric Sulphate, from Parys Mount, Anglesey. By A. H. Church, F.R.S.	13
Occurrence of Mispickel in the Stewartry of Kirkcudbright. By P. Dudgeon, F.R.S.E.	15
Augelite. By G. T. Prior, M.A., F.G.S., and L. J. Spencer, B.A., F.G.S.	16
A Note on Cone-in-Cone Structure. By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.	24
On the Occurrence of Delessite in Cantyre. By Prof. Heddle and Mr. Stuart Thomson	28
Obituary. Patrick Dudgeon, F.R.S.E.	30
Notes and Comments	32
Review	34
Abstracts	35

ORIGINALLY PRINTED IN GREAT BRITAIN BY MESSRS. WILLIAMS AND STRAHAM, LONDON. REPRINTED OFFSET LITHO BY BIDDLES LTD., THE CITY PRESS, GUILDFORD, SURREY